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CLIMATIC CHANGE AND AGRICULTURAL EXHAUSTION AS ELEMENTS IN THE FALL OF ROME

SUMMARY

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I

In history as in science the normal order is from obvious facts to hidden causes. The fact of the disastrous fall of Rome is so obvious that every intelligent person is aware of it. Its causes are so obscure that the world is still uncertain what they are. Among the many theories advanced in explanation of this great historical

event, one of the most interesting is that of Liebig,[1] which has recently been admirably restated by Professor Simkhovitch.[2] According to the view of these two authors one of the fundamental factors in the fall of Rome was a marked decline in agriculture. We are told that in the days of the Roman Republic seven jugera, or about four and one-half acres of land, sufficed for the tillage required to support an average family. Agriculture was so intensive that farms of this small size, supplemented presumably by pasture land, supported a contented, self-respecting, and progressive population. The cities, all of which were small, reflected the sturdy independence of the country people, and naturally the government was modeled to fit the citizens who administered it. By the second century before Christ, however, a great change was apparent. Under Scipio in 196 B.C. grain began to be distributed from state granaries to poor citizens. Soon came the agrarian troubles with which the names of the Gracchi are associated. Seven jugera were no longer sufficient for the average farmer. Indeed, the farmers in many places were becoming poverty stricken. Instead of sowing their fields with a scientific rotation of carefully tilled crops, they were turning them over to pasturage. Cato declared that good pasturage was the best thing for a farmer, fair pasturage the second best, poor pasturage the third best, and ordinary field crops only the fourth resource. Pessimists declared that in their wheat fields the farmers reaped only four times the seed that they sowed. In later centuries, especially from the second century A.D. onward, conditions became still

[1] Justus von Liebig, Die Chemie in ihrer Anwendung auf Agricultur und Physiologie. 9te auflage, 1876, pp. 51 ff. For this reference and others I am indebted to Professor Taussig

[2] V. G. Simkhovitch, "Rome's Fall Reconsidered," Political Science Quarterly, June, 1916.

worse. Many farms were utterly abandoned, the land was concentrated in the hands of a comparatively few large proprietors. The tenants fell into chronic debt and were little better than slaves. So eager were many of them to escape from the thraldom in which their poverty kept them that they flocked to the cities, until laws were passed which bound them to the soil as serfs. All these and many other evil consequences appear to have flowed from a widespread decline in agriculture, which, tho alleviated at times, grew worse and worse until Rome finally fell.

The difference between Roman agriculture in early and in later times has given rise to a warm debate. One side is represented by Durneau de la Malle.[1] As he put it: "A vicious system of agriculture, a biennial rotation, the ignorance of the methods of alternation of crops, the too frequent rotation of wheat on the same land, the insufficient and poor preparation of manure, the slight extent of artificial grasslands, the small number of animals supported on cultivated crops, the imperfection of the methods and instruments of culture, the vicious practice of burning the straw in place of converting it into manure — these and a hundred other deadly practices which it would be too long to enumerate form the conflicting but true picture which Greek and Roman agriculture on the whole present to us." Rodbertus [2] strongly contested this view. He attempted to show that the Romans had a most admirable system of agriculture, being familiar with the rotation of crops and the use of fertilizers, and that more labor was expended per acre than is now spent on the best fields of Germany. That there was agricultural decline he

[1] Quoted by Rodbertus in the paper cited below.

[2] Rodbertus, "Zur Geschichte der agrarischen Entwicklung Roms unter den Kaisern," Jahrbücher für Nat. Oek., vol. ii, (1864) pp. 213–19.

admitted, but he ascribed it to social causes. In the writings of such men as Varro, Cato, Pliny, and Columella he accepts the parts which indicate that the science of agriculture was highly developed, but says that other portions must be taken " cum grano sallis." He thinks the Latin writers have been misunderstood or that their statements can be explained by other circumstances. For instance, he supposes that when Rome was able to reach out and obtain grain from other lands the Italian farmers turned their attention to vineyards, olive orchards, and cattle raising, and only the worst fields in Italy were devoted to wheat. Hence it was not surprising that the farmers reaped only four times what they had sowed.

Professor Simkhovitch ably shows that these two views are not really contradictory. The picture painted by Rodbertus indicates the condition in the early days, when Rome was in her prime. The other presents the conditions of later times. Simkhovitch ascribes the difference to exhaustion of the soil. Such exhaustion, as he says, is not a necessary consequence of wrong cultivation, but arises only when unwise methods are pursued. As Van Hise[1] points out, the most crucial element in the exhaustion of the soil is the depletion of the phosphorus, which can be prevented only by abundant fertilization.

The idea that such depletion plays an important part in the decline of nations finds frequent expression. Fetter,[2] for example, expresses a not uncommon view when he says that in Asia " the effects of bad husbandry " have caused " lands that once supported millions of people, perhaps tens of millions " to become

[1] C. R. Van Hise, The Conservation of Natural Resources in the United States, 1912, pp. 322 and 338.

[2] F. A. Fetter, Economic Principles, 1915, p. 445.

deserts. He even goes so far as to imply that the decline of Egypt as well as of Rome was due largely to this cause. No one, however, has stated this view more authoritatively than Liebig.

The opponents of Liebig's hypothesis fall into two classes: these who, like Rodbertus, ascribe the fall of Rome to social and political causes, and those who believe that altho it was due to physical causes, exhaustion of the soil was only a minor factor. One of the first to expound this latter view was Conrad.[1] He was ready perhaps to accept Liebig's statement that " the productivity of the soil alone has caused the rise and fall of nations, and, in a word has made history," but not as it was meant. Speaking of Mesopotamia and the accounts given by Herodotus and Pliny of the marvelous grain crops in ancient times compared with the present sterility of the country, he says: " If we put with this fact the observation of Herodotus that the climate of Assyria was too moist for vineyards, one is led to the conclusion that a decrease of precipitation has taken place, that the present water supply and the present aridity did not prevail in antiquity — a conclusion which alone is enough to explain the present desert condition of the country." He also showed that there is similar evidence of a diminution of the water supply in Greece and elsewhere, while he thought that in Italy volcanic disasters and deforestation were great factors in causing historic decay.

In the half century since Conrad challenged Liebig's interpretation, our knowledge of the climate of the past has increased. Today there is a large body of evidence which seems to indicate that climatic changes have occurred during the last two or three thousand years, and that they may have caused many of the results

[1] J. Conrad, Liebig's Ansicht von der Bodenerschöpfung, Jena, 1864.

which Liebig and Simkhovitch have ascribed to exhaustion of the soil. The fact of a ruinous decline of agriculture not only in Italy, but in many other lands, can scarcely be denied. Its consequences were clearly disastrous. If climatic changes may have been responsible for the decline, it is well to discuss the general problem of changes of climate before proceeding to a consideration of Rome specifically.

II

Four chief climatic hypotheses have held the field. Their key words are (1) uniformity, (2) local changes, (3) progressive world-wide change in one direction, and (4) pulsatory or irregular changes sometimes in one direction and sometimes in another.

The evidence as to the climate of the past is primarily geological, even tho we are dealing with historical times. Ruins are to all intents and purposes fossils, while alluvial deposits, river terraces, old lake strands, the amount of salt in enclosed lakes, and the character of extinct vegetation and animals all belong primarily in the field of geology. Hence geologists are the men best fitted to weigh the evidence and to decide as to the climate of the past. The general attitude of the American geologists who have specialized in climatic studies may be judged from the following quotation from a letter written by Dr. W. D. Matthew in response to a series of questions sent out by the author: "As a geologist, accustomed to the concept of a changing earth, which must needs involve climatic changes, I should demand proof before I would admit that there had been *no* change within two thousand years. Such evidence as I know of points to considerable changes at various localities within the past few thousand years."

Altho geologists have abandoned the old idea of climatic uniformity, students in other lines are less completely in accord. Accordingly, let us examine the four hypotheses and see how they appeal to various kinds of students. The hypothesis of climatic uniformity is still held by a small minority of meteorologists. Their strongest argument is that altho the meteorological records of the past one hundred years show a constant recurrence of short cycles, they do not show any progressive change in one direction. Omitting rainfall records, which all admit to be too unreliable for accurate conclusions, they pin their faith to temperature. They forget that according to the best authorities on the glacial period the mean temperature of the earth at that time was possibly only 10° F. lower than at present, and certainly not more than 15° or 20°. As the last glacial period almost certainly culminated at least 20,000 years ago, and perhaps much more, the average change of temperature from that time to this cannot have exceeded a tenth of a degree per century. Early meteorological records are too few and inaccurate to permit us to detect a change of even half a degree in a century. Hence it seems scarcely allowable to use them as an argument in favor of a climatic uniformity, which geologists almost unanimously reject.

Among historians another type of argument is frequently advanced. They admit that the ruins of western Asia and northern Africa, the depopulation of the lands around the Mediterranean Sea, and the decline in agriculture and commerce in that region all look as tho they were the result of climatic changes. But appearances, they say, are deceptive. Misgovernment, pestilence, war, and the inevitable decay of an old civilization are the causes of these signs of decay. The value of this argument may be judged from the words of Professor

Simkhovitch.[1] "The steady shrinkage of population in the ancient world did not follow, curiously enough, in the wake of its bloodiest wars, but in times of complete peace. The fearful losses of Rome's greatest wars on the other hand, losses for instance occasioned by the Punic Wars, were rapidly made up, and in spite of further wars the population was steadily increasing. The same was true of the temporary decrease of population occasioned by a plague, Different was the situation in the period under discussion [that is, the period of the steady decline of Rome]. Losses occasioned by war and plagues were never made up, and during the longest and profoundest peace that Rome ever enjoyed the Roman population was steadily shrinking and its national strength steadily melting away."

One of the most forceful arguments in favor of climatic uniformity is the undeniable fact that in ancient times people suffered severely from aridity. The seven years' famine in Egypt during the days of Joseph is only one among hundreds of cases where ancient historical records prove that great distress arose from temporary failure of the crops for lack of water. To prove that people suffer from drought, however, proves nothing as to the average rainfall. Countries with an average of fifteen inches of rain per year suffer from famine if the rainfall is reduced to ten inches for a few years. In the same country a rainfall of twenty inches per year would cause famine if the average were thirty inches. Such a famine would be worse than the one caused by ten inches, for more people would live in the country when the rainfall was larger, and the suffering would be correspondingly greater. Hence altho the argument from famine proves unmistakably that there was less rain at

[1] V. G. Simkhovitch, "Rome's Fall Reconsidered," Political Science Quarterly, p. 226, June, 1916.

a certain time than at some preceding time, it sheds little light on the relative amount of rain two thousand years ago and now.

Another argument in favor of climatic uniformity is the Roman water works in Syria, North Africa, and elsewhere. Would the Romans ever have gone to such labor if they had not felt the pinch of aridity? Look at the tunnels of Kharga, the reservoirs of Cyrene, and a hundred similar works. Do they not prove that water was so scarce that every drop had to be hoarded? One can only answer that unquestionably water was scarce, but the case is like that of famines. Water may be scarce with a rainfall of ten inches or thirty. It all depends on how many people there are.

Let us examine two specific cases: Cyrene in North Africa, and Ilandarin in Syria. Professor J. W. Gregory has made a careful study of the water supply available at Cyrene both from the springs and the reservoirs. He thinks that in that dry climate the minimum allowance per day for each inhabitant is eight or ten gallons, for this would have to suffice not only for household purposes, but for cattle and flocks, and for the irrigation of gardens. Hence he concludes that Cyrene can never have had more than about 25,000 inhabitants, for he does not admit that the climate may have changed. The ruins, however, are of great size and magnificence, and suggest a population far in excess of 25,000. Dr. D. G. Hogarth, who is one of the best authorities on such matters, states that there is "surprisingly good" authority that Cyrene had at least 100,000 inhabitants.[1] This case is typical of scores. The natural interpretation is that the water supply was once more abundant than now. If it be assumed that there has been no change of climate, we must also assume that the his-

[1] J. W. Gregory, Cyrenaica, Geographical Journal, vol. 47, p. 321, London, 1916.

torical and archeological evidence as to the importance of such places is misleading.

Ilandarin is a striking ruin on the borders of the Syrian Desert fifty miles northeast of Homs. According to Professor H. C. Butler, the nearest water is now two hours away to the west.[1] Yet once Ilandarin was a large city, walled and containing at least ten churches whose ruins are still visible. Like other Roman towns it had its water works. A great reservoir stood at one end of the town, while near the center was a large bath located higher than the reservoir and therefore drawing its water from some other source. The city covered an area about a mile square. Its population, according to Professor Butler, must have been at least 20,000 and may have been 100,000. Its case is like that of Cyrene, only far worse — today water enough for not a single inhabitant, formerly enough for tens of thousands and for a wasteful institution like a Roman bath.

In order to reconcile such facts with the hypothesis of climatic uniformity, it is necessary to suppose that earthquakes may have diverted underground waters, or that there were formerly tunnels of great magnitude which have fallen into ruin and whose location is no longer known. If Ilandarin were the only case of the kind, such reasoning might carry weight. But it is literally only one among thousands scattered from Mongolia to Gibraltar, and from Texas to Arizona and Sonora. If ancient water supplies have been diverted from all these places, there ought to be great numbers of cases where the water is found in some new location not far away. But I know of no case where supporters of the hypothesis of climatic uniformity have even attempted to point out what has become of the water

[1] For a full statement of Professor Butler's views see "Palestine and its Transformation," Boston, 1911, p. 291.

in any specific instance. Moreover, when the old aqueducts are diligently searched out and repaired, as at the oases of Kharga in the Libyan Desert and Palmyra in the Syrian Desert, the water that is forthcoming appears always to be utterly inadequate to the size of the ruins and to the labor spent on the ancient water works. Hence the logical conclusion seems to be that in late Roman times there was not indeed as much water as the inhabitants wanted, but much more than at present.

The chief bulwark of the hypothesis of climatic uniformity is the evidence of vegetation. Again and again we are told the classical writings furnish abundant evidence that in the past the crops of a given country were in general the same as at present. Ignoring such plants as the famous medicinal herb known as sylphion, which once grew abundantly in North Africa, but has now completely disappeared, believers in climatic uniformity dwell on the vine and the palm. These two plants grow in areas which are almost mutually exclusive. Only in a narrow strip will both flourish together. This strip includes Palestine today, and included that country in classical times. A change of 2° or 3° F. in mean temperature would exclude the palm if the temperature were lower and the vine if it were warmer. Therefore, there has been no change of climate. This argument has seemed conclusive to many people, but it ignores two essential points. In the first place, in subtropical regions with winter rains and dry summers the crops are essentially the same whether the rainfall is fifteen inches or thirty. If there is doubt of this, compare the gardens and fields of Damascus with those of the western side of the Lebanon Mountains where the rainfall is at least twice as great. In Greece the rainfall on the west coast is twice as great as in Attica, but irrigated areas

in Attica raise everything that is raised on the west coast. Therefore, the fact that the crops today are essentially the same as those of the past does not show whether the rainfall has increased or diminished. In the second place, the argument as to uniformity on the basis of vegetation ignores the conclusions of geologists. To the layman it may seem scarcely credible that a change of only 10° or 20° F. could shroud eastern North America in ice as far south as the Ohio River; but we must accept the decision of the specialists. If the climate two thousand years ago differed from that of the present one-tenth as much as today's climate differs from that of the glacial period, the fact would be of the utmost significance; yet it would involve a change of mean temperature amounting to less than 2° F. This would not exclude either the vine or the palm from Palestine, and would not be appreciable in such rough records of agriculture as have come down from classical times.

Taken all in all the hypothesis of climatic uniformity does not seem to be well grounded. It is directly opposed to the conclusions of geologists. The arguments in its favor, so far as they are based on temperature, are inconclusive because whatever change of temperature has occurred appears to be very slight. The arguments based on ruins are also inconclusive, because they depend merely upon the assumption that something may have happened to destroy the water supply; they offer no proof as to what has happened. The evidence afforded by famines and ancient waterworks fails like the other evidence in proving climatic uniformity. It proves that in the past some periods have been drier than others, but it does not prove that the average conditions then were the same as now.

If the preceding discussion is sound, we must conclude that climatic changes have taken place during historic

times. The next step is to choose among the three types of change, namely, local changes, a progressive or steady change in one direction, and pulsatory irregular changes. Local climatic changes have often been supposed to be due to human activities, such as the cutting of forests, the opening up of a country to agriculture, the introduction of irrigation. Geographers, geologists, and meteorologists, however, are now practically unanimous in believing that such actions produce only slight climatic effects. In spite of innumerable statements to the contrary, it seems almost certain that northern China, for example, does not owe its unfavorable climate to the cutting down of trees, but owes the absence of trees to the dry climate. The wholesale destruction of forests may work havoc if the ground is swept bare by fires and the soil is washed away, but this does not appreciably change the rainfall. Unwise agriculture or excessive pasturage of sheep and goats may allow the soil to be washed away from the hills, but this again does not appreciably change the rainfall, altho it greatly alters the habits of the rivers and springs.

The hypothesis of a progressive and world-wide climatic change in one direction has also been practically abandoned by geographers.[1] The almost universal

[1] This statement is based partly on the fact that during the past ten years even such defenders of the hypothesis of progressive climatic changes as Kropotkin have modified their views in the direction of irregular or pulsatory changes. (See Geographical Journal, vol. 43, p. 451, London, 1914.) It is also based on the answers to a series of questions recently sent out by the writer to the members of the Association of American Geographers, to a list of geologists selected by Professor Joseph Barrell, to the Climatic Committee of the Ecological Society of America, and to a few meteorologists not included among the geographers. Among those from whom replies have thus far been received only three believe unequivocally in climatic uniformity during historic times. Only one thinks that changes have occurred mainly through human actions, altho a considerable number believe that these have been of subsidiary importance. Three accept the idea of a change which progresses steadily in one direction. The remainder, forty-nine in number, believe that during the past two or three thousand years climatic changes have taken place on a scale greater than during the past century. Practically all of the forty-nine hold that while there have been irregular or pulsatory changes, the general tendency has been toward greater aridity in the Mediterranean countries and other similar regions.

opinion of geologists, as we have seen, is opposed to the idea of any long *steady* change in one direction. Of course, the net result of the 20,000 to 30,000 years since the Glacial Period has been a change in one direction, but this change appears by no means to have taken place regularly. In the same way, during the historic period there appear to have been similar irregularities, altho the general tendency has been toward less favorable rainfall in southern Italy and the other lands around the Mediterranean. Elsewhere, for example on the southern border of the subtropical desert belt, the change may have been in the opposite direction; but that does not now concern us.

III

If pulsatory climatic changes have taken place, they may have been of such widespread historical importance that it is worth while to consider the evidence in regard to them. When the climatic facts of historic times are carefully sifted, certain epochs present evidence indicating a change in one direction, while other epochs indicate the contrary. For example, the somewhat vague accounts of the Caspian Sea before the time of Christ seem to be much more intelligible if the lake stood about 150 feet higher than now, so that it almost coalesced with the Sea of Aral. Strabo, writing about 20 A.D., gives data as to the distance from the mouth of the Phasis River in the Black Sea to that of the Cyrus in the Caspian, as to the size of the sandy plain on the west coast of the Caspian, and as to other features. From his figures, Khanikof estimates that at that time the sea stood about eighty-five feet higher than now.[1]

[1] Humboldt's Asie Centrale is perhaps the greatest source of information on this subject. For a summary of his results see The Pulse of Asia, by the present writer, pp. 327 ff., Boston, 1907.

Six or seven centuries after Christ the lake had fallen to a level fifteen feet or more below that of today, as is proved by the presence of old walls submerged beneath the water on both the east and west coasts. By the tenth century, however, the water had apparently risen at least twenty-nine feet above the present level, and later it rose still higher. The Arab geographer Istakhri, for instance, says that in his day, about 920 A.D., the water rose to the sixth tower of the wall at Derbent; and as that tower can still be identified, we have an exact determination of the lake level.[1] A ruined caravanserai at Baku stands in water fifteen feet deep, and appears to indicate that about the twelfth or thirteenth century the lake again stood at a low level. Still later, in the early fourteenth century, Sheikh Sefi-Eddin tells us that the lake rose to a certain holy grave which now lies thirty-seven feet above the present datum level. This last change of level was possibly due in part to variations in the course of the Oxus River. The drowning of the "Dragon Town" in Chinese Turkestan, however, by the rising of the waters of Lop-Nor, indicates excessive rain at this very time in Central Asia.[2] The occurrence, between 1290 and 1450 A.D., of the five coldest winters on record, if we may judge by the freezing of the Baltic Sea, proves that this was also a time of peculiar climatic severity in northwestern Europe.[3] Moreover, the Dead Sea and certain lakes, such as Gyöljuk in Turkish Armenia and Seistan in Persia, are known to have fluctuated in the same way as the Caspian Sea, and at approximately the same time, so that the climate must have varied from century to century.

[1] See E. Bruckner, Klimaschwankungen seit 1700, Vienna, 1890.

[2] See The Pulse of Asia, pp. 287, 344.

[3] A. Norlend, Einige Bermerkungen über das Klima der historischen Zeit. Lunds Univ. Arsskrift, N. F. Abd. 1, Bd. 10; No. 7, 1914.

In America similar climatic fluctuations appear to have occurred during the same period. For example, geologists and engineers calculate that the amount of salt in the water of Searles Lake in southeastern California gives almost certain evidence that the lake must have overflowed and been fresh only two thousand or three thousand years ago. This it could only do by standing about 180 feet above the present level and expanding to two and a half times the present size. Old beaches and other deposits prove that during the two or three thousand years since the lake overflowed the level has in general fallen, but has fluctuated, sometimes falling rapidly, and again rising. The dates of these fluctuations can be determined from the growth of the giant sequoia trees fifty miles away on the other side of the Sierras. In a climate such as that of southern California having a long dry summer, the thickness of the woody rings furnishes an approximate record of the rainfall. This record, as read from 450 sequoia stumps, agrees in general with the pulsations of climate inferred in Asia. Thus in the parts of both the Old and the New World having the Mediterranean type of climate there is evidence of the same kind of irregular changes.

A single concrete example will illustrate some of the ways in which such changes may have influenced the drier regions of the Roman Empire. About the time of Christ the oasis of Palmyra in the Syrian Desert was famous for the sweetness, purity, and abundance of its waters. Today no one in his right mind would praise it for any of these qualities. The brackish water smells strongly of sulphur, and the natives are always disturbed by its scarcity. The gardens, tho pleasant in themselves, seem sadly forlorn and insignificant in their setting of vast ruins. In its prime Palmyra covered at

least as much ground as modern Damascus, and probably had 150,000 inhabitants. Today it has only 1500 at the most. The city reached its greatest prosperity in the third century of our era, when the water supply was apparently diminishing rapidly. This is what might be expected according to the climatic hypothesis. Written records and ruins show that important roads once crossed the Syrian Desert from Petra in the south and from the western Bosra in the latitude of the Sea of Galilee. These roads are today impractical for caravans because of the absence of water and grass. They appear to have been finally abandoned in the second century because of increasing aridity. This naturally threw all the trade between Egypt, Syria, and Damascus on the one hand, and Mesopotamia and Persia on the other, to the route through Palmyra, and thus greatly stimulated that city. By the seventh century, however, when the Mediterranean lands and western Asia apparently became more arid than at any other known period, Palmyra was practically abandoned. In the tenth century, when the water supply for a while became more abundant, it enjoyed a partial recovery, only to decay once more during the next dry epoch. Today the water supply varies directly in harmony with the rainfall of the past few years, and the size of the village changes correspondingly.

Before applying our climatic hypothesis to the fall of Rome, let us gain a clearer idea of the precise changes that have probably taken place in Italy. It does not seem that at any time within the last three thousand years the country had a climate like that of either central Europe or northern Africa. At all times the general character of the seasons has presumably been the same as now. There have been abundant rains in winter and a diminished rainfall in summer. The temperature, as

already pointed out, has apparently not been essentially different from what it is today. The change appears to have been primarily in storminess. As nearly as can yet be determined, tho the winters two thousand to three thousand years ago were not essentially different from those of today, the storms may have been more numerous and more severe. On an average the winds were probably stronger than at present. Therefore, the warm wave which precedes a winter storm was warmer than now, and the cold wave which follows was correspondingly colder. Such conditions would have little effect except upon the sturdiness of the people; but this, as we shall see, may be of far-reaching import.

In the autumn, and especially the spring, the difference between the past and present was apparently greater than in the winter. In the autumn the stormy period probably began somewhat earlier than at present, while in the spring it lasted later. Judging by present conditions in years which go to one extreme or the other, the greatest difference was in the spring. At that time not only were the storms apparently more severe than they are today, but they continued so much later in the season that the total spring rainfall, which is the most essential for agriculture, increased in a greater ratio than did the rainfall at other seasons. Finally, the summers two or three thousand years ago apparently had about the same average temperature as today. Then as now they were decidedly less stormy than the spring. Nevertheless, in summer, as well as at other seasons, the storms of that time seem to have exceeded those of the present both in number and in severity. Hence while the summers were warm, sunny, and comparatively dry, they seem to have had more rainfall than now and to have been more subject to the pleasant changes which mitigate the effects of long steady heat.

There has been so much misconception about this matter that it is necessary to emphasize it. Even if there have been important changes of climate, the succession of seasons in the past was in general like that of today. The chief difference lay (1) in somewhat more abundant rainfall at all seasons and a decidedly greater abundance in the spring, and (2) in greater variability, which would be of chief importance in warm weather. This variability apparently caused the past climate to have more than now of the stimulating quality which today differentiates such a climate as that of Germany, England, or the northeastern United States from that of such countries as Greece or Spain. In general the climate of Italy, from Rome southward — the part of the country with which we are mainly concerned in classical times — resembled that which now prevails in the northern part of the country, but was probably even better at certain periods.

In order to assign to climatic changes their due importance in history it is necessary to understand not only the nature of the changes, but their periodicity. This can best be done by means of diagrams such as I have published in my book *Civilization and Climate*. Figure 33 in that volume (p. 228) shows the variations in the rainfall of western and central Asia as inferred from ruins, lakes, famines, old roads, and other evidence available previous to 1910. The solid line shows changes of climate in California on the basis of the growth of the Big Trees measured in 1911 and 1912. Later studies indicate that the dotted line should be modified as indicated by the dashes and also in certain other respects — for example, about 400 B.C., where it should rise higher. The original curve, however, is reproduced in order to show the resemblance between the conclusions reached in two continents by wholly

diverse methods. In general, the two lines of Figure 33 indicate that approximately the same changes have taken place in similar climates in the two hemispheres. It would not be justifiable, however, to assume complete similarity in all the details. Moreover, according to conclusions reached simultaneously and independently by Penck in Europe and by the writer in America, climatic changes seem to consist of a shifting of the various zones first toward the equator and then away from it. Accordingly, a change may occur in one place somewhat later than in another.

Altho the results presented in *Civilization and Climate* are by no means final it seems allowable to use them as the basis of a study of the fall of Rome. While not applying directly to Italy, the curve of the Big Trees seems to show the main trend of events in that country as well as in California.[1] Omit-

[1] It may seem at first sight that Italy and California are so far apart that the record of the Big Trees cannot safely be applied to the problem of this paper. Such, however, is not the case, as appears from three lines of evidence: (1) The growth of the trees is the only means thus far available for actually measuring the effect of climate year by year throughout the historic period. Therefore until further data are available it is our best yardstick. Recent studies of the relationship between present variation of atmospheric pressure or temperature in widely separated parts of the earth make it practically certain that a change in California must be accompanied by a change in the Mediterranean region. The question is whether the changes in the two regions are of the same kind. (2) A comparison of the two curves of Figure 33 in Civilization and Climate shows that in general similar variations have taken place in California and western Asia. The agreement of the two curves is particularly noticeable from 800 A.D. to the present time, that is, during the period when the data are most abundant. Moreover, since the Asiatic curve was prepared, in 1910, a good deal of new evidence has become available. It all indicates an agreement between the Asiatic and California climates. For example, the explorations of Stein in Central Asia indicate that the second century B.C. was drier than appears in the dotted line of Figure 33. The statements of Herodotus, on the other hand, seem uniformly to point to abundant moisture in the second half of the fifth century B.C., thus harmonizing with the tree curve. (3) The third and strongest reason for thinking that tree growth in California may be used as a measure of the rainfall of southern Italy is the fact that at the present time the two phenomena vary in harmony. Let us confine our attention to the months from March to July, since they are critical for agriculture in both California and the Mediterranean countries. The two longest rainfall records in California, those of San Francisco and San Diego, give an idea of the main climatic fluctuations in southern California since 1851. Figures are available for a comparison of these fluctuations with the annual growth of 112 sequoia trees in the Sierra Nevada Mountains, and with the rainfall at Rome, Naples, and Jerusalem for the fifty-five years from 1851 to 1905.

ting the earlier and more doubtful centuries, it appears that from 450 to 250 B.C., Italy probably enjoyed a highly favorable climate. During the next fifty years there was marked deterioration. Throughout the second century, conditions were less favorable than before, altho on the whole they were improving. Even

The method of comparison is to arrange the years of each record in order according to the amount of rain in California. The years are then divided into the four groups indicated below, and the averages are obtained. In computing the tree growth the averages for the three years beginning with a certain condition of rainfall have been used in one case, and the third year after a given rainfall in the other. This is because the growth of the sequoias depends more upon the rainfall of preceding years than upon that of the year in question.

Groups of Years

I. 7 years with heaviest rainfall in California, i. e., an average of over 6.5 inches.
II. 18 years with heavy rainfall in California, i. e., 3.9 to 6.4 inches.
III. 17 years with light rainfall in California, i. e., 2.7 to 3.8 inches.
IV. 13 years with least rainfall in California, i. e., less than 2.7 inches.

The average rainfall (columns A to D) and the average growth (columns E and F) for the four groups are as follows:

	Average Rainfall				*Average Growth of Trees*	
	A	B	C	D	E	F
	San Francisco and San Diego	Rome	Naples	Jerusalem	3 years	Third year
I.	8.3 in.	10.7 in.	11.5 in.	7.0 in.	3.02 mm.	3.07 mm.
II.	4.5 "	10.6 "	11.0 "	6.3 "	3.00 "	3.04 "
III.	3.4 "	9.8 "	9.2 "	5.6 "	2.98 "	2.99 "
IV.	1.9 "	9.6 "	8.6 "	5.2 "	2.92 "	2.84 "

Without exception all the columns from B to F vary in harmony with the California rainfall, A. At Rome the agreement with California is less marked than at Naples, while at Naples, when reckoned in percentages, it is less noticeable than at Jerusalem. At Palermo, however, the agreement is probably at least as marked as at Jerusalem, as appears from the following table for the twenty-six years for which rainfall records are available at the time of writing.

(1)	10 years with average rainfall of 5.8 in California	Average 8.3 at Palermo.
(2)	8 " " " " " 3.6 " "	" 7.6 " "
(3)	8 " " " " " 2.4 " "	" 6.2 " "

The Indian Meteorological Service has shown that in winter and spring storms of a certain type pass from the western Mediterranean across Syria, Mesopotamia and Persia to northern India. This type of storm appears to increase when the rainfall is abundant in California and the sequoia trees grow rapidly. This does not mean that a single year of heavy rainfall in California is sure to be accompanied by abundant rain in Italy and the other Mediterranean lands. It does mean, however, that at present when any considerable group of years is considered, the growth of the sequoias indicates the general conditions of rainfall in those countries. Presumably the same was true in the past. So far as can be judged from the growth of the sequoias and from the other data now before us, it appears as if the rainfall of southern Italy during the months from March to July at the time of Christ may have been from 50 to 100 per cent greater than at present.

at the worst, however, they were distinctly better than today. From 100 B.C. to 50 A.D. more favorable conditions ensued, altho not equal to those during the pristine days of the Roman Republic. Next came a sudden deterioration so that the second century of our era was unfavorable, altho possibly not so much so as the second century before Christ. After a slight recovery at the end of the second century and the beginning of the third, there began a long and steady decline in climate until the final fall of the Western Empire. The next century and a half saw a slight improvement until the beginning of the seventh century. Then followed the two worst centuries of the historic period, altho possibly the thirteenth century B.C. may have been almost as bad.

Turning now from the physical side of our problem, let us consider the probable historic results of the adverse climatic changes that appear to have taken place between 250 B.C. and 650 A.D. It will be understood that the reverse of what is here described is supposed to characterize favorable changes.

IV

We may divide the results of climatic changes into three groups: economical, political, and biological. For a statement of the economic conditions I cannot do better than refer to Professor Simkhovitch's article already quoted. I do not agree with him in thinking that exhaustion of the soil was the primary cause of the conditions which he describes, for in countries like Syria cultivation by the methods which he deplores has continued for thousands of years, and people are still fairly prosperous wherever water is abundant. Nevertheless, his description of the decline of agriculture is

most weighty. In showing " how the great agricultural scholars of the time analyzed the situation," he quotes the following extracts from Columella, who wrote about 60 A.D.: " I frequently hear the most illustrious men of our country complaining that the sterility of our soil and intemperate weather have now for many ages past been diminishing the productivity of the land. Others give a rational background to their complaints, claiming that the land became tired and exhausted from its productivity in the former ages, and hence the soil is no longer able to furnish sustenance to mortals with its former liberality." [1]

This quotation sets forth two theories as to the cause of the agricultural decline of Rome. In Columella's day the most illustrious men of Rome apparently complained that a change of climate had for ages been producing sterility and thus diminishing the crops. Others, whom Columella thinks more rational, believed that the soil of Rome had become exhausted. Nevertheless, as Columella himself points out, the Romans in the former ages were familiar with the most effective methods of cultivation. As Simkhovitch puts it, " the intensive farming of the Romans on seven-jugera farms, was like the farming of the Chinese and Japanese, very intensive, their small grain fields being planted in rows, hoed, and weeded and carefully manured with excrements and ashes and stable dung. The experience of China and Japan has shown that on very small land plots such intensive agriculture can maintain itself indefinitely without any recourse to scientific repletion of the soil by mineral fertilizers."

In view of this we must apparently assume either a most profound and astonishing change in Roman

[1] This passage had already been quoted by Liebig, Die Chemie in ihrer Anwendung auf Agrikultur. . . . 9th ed., p. 53.

character, or else a change of climate. If the Romans knew how to farm like the Chinese and Japanese and thus indefinitely to ward off the effects of the exhaustion of the soil, but failed to do it when they found themselves falling into dire distress, they surely had suffered an "inner decay" that is scarcely conceivable. On the other hand, if they had not rain enough in the late spring, no amount of care and cultivation would make it possible to carry on intensive agriculture.

One of the most notable features of the curve of tree growth in California was the decline from about 250–200 B.C. If a similar change occurred in the rainfall of Italy it would tend to kill the forests or at least to reduce their density and render them an easy prey to fires and to the depredations of sheep and goats. Hence the soil would be left unprotected, and the rains of winter would wash it down to the lowlands and thus spoil many a good farm in the way that Simkhovitch well describes. In their place great swamps would be formed. Few people realize that some of the greatest swamps are located in the driest countries. In Transcaspia I have waited two weeks to cross the flooded tract at the lower end of the Tejen river; in Persia my camels were nearly drowned in crossing a swamp; and in Chinese Turkestan I was nearly engulfed in a grave of mud when the camel that I rode and two others broke through the apparently solid earth into a stinking morass.

In the later days of Rome, *pari passu* with the deterioration of the climate, agriculture progressively declined. Thus by 395 A.D. "the abandoned fields of Campania alone amounted to something over 528,000 jugera." Doubtless much of the land thus abandoned was capable of being restored, for even then the climate was apparently better than at present. That it was not

restored seems merely to mean that when people are waging a losing fight against nature they become discouraged. The change is what counts. A carpenter with an income of $1200 a year feels prosperous, whereas a banker who has had $50,000 a year would feel himself in dire proverty if his income were reduced to $5000. The banker can in time accommodate himself to a diminished income; but suppose that a few years later his income falls to $4000, then to $3000, and finally to only $1500. He may still have more than the carpenter, but he would have to take his children out of college, sell his automobile and house, give up keeping servants, and so utterly change his mode of life that he would feel his condition to be most pitiable.

So it is with countries. In the fourth century B.C., Italy appears to have been favored with so fine a climate that less than five acres was enough to support an average family. Cultivation was highly intensive so that the most advanced methods of agriculture were developed. Failures of the crops were rare, and general prosperity prevailed. The farmers lived in comfort on their little farms and asked nothing of anyone, and the towns reflected their condition. Then when the spring and summer rains diminished — to speak by hypothesis — a small tract of land was not enough to furnish a living for the farmer and his family. Crops that had previously been profitable ceased to be worth while, the farmers ran into debt, and their lands gradually fell into the hands of large landowners. Since crops were no longer profitable the land was used for grazing purposes, as classical writers often point out. This was bad in two respects. In the first place, sheep and goats eat not only grass, but seedling trees, and thus prevent the growth of new forests. Where they pasture in abundance the soil is badly trampled, and is no longer held in

place by roots. Hence it is washed away by the winter rain, leaving the hillsides barren and ruining the fields in the lowlands. In the second place, sheep-raising and cattle-raising demand large areas. Hence they increase the tendency toward the concentration of land in the hands of a few individuals. During the Augustan Age the farmers apparently recovered somewhat, and presumably were better off than in the second century B.C. Then came renewed climatic stress at the end of the first century A.D., and later the long deadening decline that culminated in the seventh century. In those days the Roman farmer was in circumstances as discouraging as those of the banker with a mechanic's income.

Such economic changes must inevitably produce political results. One of the first and most obvious is a disturbance of the system of taxation. Theoretically, taxes ought to be proportioned to the income of the people who pay them. Practically the adjustment is most imperfect, and has a disagreeable way of remaining fixed when other conditions change. When crops are bad the expenses of the government do not diminish. A tax which was easily paid from a full grain bin becomes oppressive when the grain bin is half empty. It is not surprising that the people were discontented and agrarian reforms were needed in the days of the Gracchi. At that time Rome apparently suffered from climatic conditions more unfavorable than at any other period previous to about 300 A.D. Under such circumstances the poverty and discouragement of the many almost inevitably favor the concentration of power in the hands of a few. Hence democracy suffers and a plutocratic form of government is superimposed upon the old framework. It would be useless to illustrate the matter here, for I should merely be repeating the arguments of Professor Simkhovitch—the only dif-

ference between his view and mine being in the interpretation of the cause of the agricultural decline. Not only Rome itself, but the provinces were suffering, and it is not strange that their discontent was finally an important element in the break-up of the Rome Empire.

The theory that agriculture declined because of exhaustion of the soil seems to have little bearing on barbarian invasions. In this respect it is diametrically opposed to the theory of a decline due to climatic changes. Nomads such as those of central Asia are the first to feel the effect of increased aridity. The springs that they have been wont to frequent on the edge of the desert dry up, grass for pasturage is scanty, and therefore they begin to seek new pastures. At first they may meet with no special difficulty, provided the country is not too densely populated. Soon, however, they come into conflict with neighbors who also press into the well-watered regions where there is abundant grass. When tribe meets tribe and there is not enough grass for all, conflict is bound to ensue. Then the tribe which is obliged to content itself with the less favorable locations is practically certain to take to plundering. It may plunder its nomad neighbors, or it may make raids on the settled villages in the oases or in the better-watered tracts on the desert border.

Any one who has lived in the deserts of Asia knows how this happens. In Palestine and the Syrian Desert, for example, the year 1909 was characterized by an unusually dry spring. What happened? The nomads pushed their way in among the settled population of the cultivated land. Dr. Patterson, a missionary physician at Hebron, says that in his hospital he operated upon gun-shot cases that year to an extent unprecedented in his sixteen years in the country. Within two months I myself had four experiences with raiders. First a party

of Arabs who had already robbed some natives approached my own camp by night, but made no attack because we were on the watch; next I was sleeping in a native camp when some men of another tribe drove off all the camels; a third day we saw a band of raiders on the hills above us, and a man who had been with our party but had fallen behind only escaped by flight. Finally, a member of my escort, who had gone ahead to investigate the road, exchanged shots with a party of raiders and hid for hours before he dared rejoin us. In a good year, on the other hand, one can travel through the same country in perfect security.

If such things can happen because of the drought of a single year, what must have been the effect when aridity became more and more pronounced for centuries? Thousands of people must have been driven from their homes. Such movements begin in the driest regions, such as the great deserts of Transcaspia or Arabia. Where the nomads were met by a solid bulwark like that of the Roman Empire in Syria and North Africa, they could not achieve much; but in eastern Europe, where there was nothing to hold them back, one can scarcely doubt that they must have pressed forward. Thus one tribe would upset another, and a whole continent may have been put in commotion. This, I believe, explains to a large degree the barbarian invasions of Europe during the early centuries of the Christian era. Men do not take their wives and children and move in great masses except under some strong compulsion. I do not need to go into details on the barbarian invasions of Rome. It is enough to point out that they were numerous as long as the climate of Asia grew worse. They spread into each of the southern peninsulas of Europe. They spilled over into Africa. Finally, in the seventh century there came the cul-

minating migration from the desert. The power of the Roman Empire had vanished, and the Arabs surged out under Mohammed. The religious impulse doubtless was of the greatest importance as a unifying factor, but hunger may have been the chief impelling force. So too, in later days, Genghis Khan may have been the unifying factor, but hunger due to a second great period of aridity was perhaps the underlying force that impelled his hordes to surge out of Central Asia.

The biological effect of changes of climate are as yet not well understood. In the end, however, they may possibly prove to be even more important than the political and economic effects. It has long been known that many of the leaders both in ancient Rome and Greece belonged to the fair Nordic race. Why else do so many of the ancient painted statutes of the gods and goddesses of Greece have red or yellow hair and blue eyes? Not all the leaders, to be sure, were tall, fair Nordics; for Socrates, the greatest mind of all, was short and dark — a typical member of the Mediterranean race. Yet the fair people from the north were sufficiently aggressive and dominant to cause the favorite divinities, Zeus, Apollo, Pallas, Diana, and others to be represented as of that race. The climate of both Greece and Italy, however, is thought by many authorities to be too sunny for the blond Nordics. It often induces diseases of the skin and nerves, and in the long run apparently lessens the rate of reproduction. Thus in a climate like that of Italy, especially southern Italy, the agressive Nordic part of the population tends to diminish. This tendency would be less, however, under the conditions which we suppose to have prevailed three or four hundred years before Christ, and on the other hand, would increase with the changes of climate here described. When combined with the Roman prac-

tice of beinging in slaves from conquered countries, it may have helped to bring about a gradual change in racial type. The race which apparently provided the majority of Rome's early leaders appears to have declined in numbers, and the decline was presumably hastened by unfavorable climatic changes.

Another important factor in the biological decline of the people of Rome was perhaps malaria. Ross, Jones,[1] and others have shown that altho malaria was well known in early Rome, it did not become widespread until the second century B.C. About that time it increased greatly and finally became endemic. Any one who has been in a country where this disease is common knows what a scourge it is. At the end of a long dry summer thousands of the population succumb. They seem inert and stupid, unable to think and unable to work. Not merely are they temporarily incapacitated, but they suffer year after year, and are permanently weakened. Ross found that nearly half of the Greeks today bear marks of the disease. Its effects are mental as well as physical. The power of self-control is weakened, and so too is the power of steady thought and of assiduous application to duty. Today with quinine as a universal remedy, and with our knowledge of how to exterminate mosquitoes, malaria is losing some of its terrors; yet it remains a scourge of terrible proportions not only in Greece, but in parts of Italy and in many Oriental countries. In the old days it must have been far worse.

It may perhaps seem a far cry from changes of climate to malaria, but the two are intimately associated. Malarial mosquitoes are found from central Europe to the equator. In Italy the degree to which they

[1] Jones, W. H. S., Malaria: A Neglected Factor in the History of Greece and Rome, 1907.

flourish depends largely on the prevalence of stagnant water. Where rains are abundant at all seasons, stagnant water is rare. Swamps may of course exist, but even there the water is apt to be changed by the rains, and the larvae of the mosquito are washed away and drowned. In the streams they cannot live because of the moving water. For this reason an abundant rainfall prevents the spread of malaria except where the forests remain constantly damp. Such conditions prevail in many equatorial regions, and are one reason why malaria is there such a terrible scourge.

During the period of favorable climate which apparently prevailed in Italy three or four hundred years before Christ, the mountains were probably well wooded, and springs abundant. The streams must have been for the most part perennial, and were presumably well adjusted to their valleys so that they flowed in clearly defined channels. Increasing aridity, as we have already seen, would cause the mountains to become more barren. Consequently the streams would become heavily loaded with mud and gravel. This would be an important element not only in ruining the farms, but in increasing malaria. As physiographers well know, when streams that are heavily loaded with silt emerge from the mountains and enter the plains, they deposit part of their load. Thus they fill their channels, divert themselves into new courses, and gradually spread out into many branches which wander here and there over wide areas, and often produce swamps. When such streams dwindle during the dry summer, most of the channels are converted into mere strings of stagnant pools, ideal places for mosquitoes. Moreover, the drier the summers, the greater the need of irrigation, and this also causes stagnant pools. Thus the supposed climatic changes in Italy were mainly of a kind to in-

duce a great increase in the area where the mosquito was able to thrive. Hence the ravages of malaria were presumably increased, and played a part in destroying the self-control and energy of the Romans.

V

I have left till last what I believe to be the most important effect of climatic changes. Students of the science of ecology, that is, of the adaptation of organisms to their environment, are reaching some surprising conclusions in regard to man. It has been our boast that the human race, alone among animals, is able to dwell in all parts of the world and to adapt itself to all conditions. In proof we point to the fact that white men can live and work in Arctic regions or in tropical Africa. We also point to the fact that the human race has differentiated itself into black people, yellow people, white people, and red people, and that each of these appears to be adapted to a particular kind of climatic environment. It appears now, however, that there are two kinds of adaptation: one to sunlight and the other to temperature and humidity. The adaptation to light can apparently be made with comparative ease. It is a matter of everyday observation that in winter or when people stay in the house at any season the skin becomes pale, whereas exposure to the sun soon changes the complexion of people of fair races. In the same way a change of habitat is apparently followed by a gradual elimination of the people whose complexions are not adapted to the new environment. The adjustment to temperature and humidity appears to be much more conservative than the adjustment to light. A study of the relation of the death-rate to temperature among many races and in many parts of the world illustrates

the matter. Taking the year as a whole the number of deaths in all parts of the world varies in close harmony with the temperature. At low temperatures large numbers of people die, which means of course that they are physically weak. Under ordinary circumstances the number of deaths declines up to an average temperature of between 60° and 65° for day and night together. At average temperatures above 65° the death-rate begins to increase, and above 70°, which means when the thermometer rises to approximately 80° or more at noon, it increases with great rapidity, especially if the air is humid. Strange as it may seem, the negro or Cuban in the southern part of the United States shows scarcely more adaptation to a hot climate than does the white man, while the Finn and Swede of the far north are weakened by low temperature almost as much as is the negro. The Japanese death-rate shows that that race also thrives under practically the same conditions as do the whites and negroes.

Other tests also indicate that a mean temperature of from 60° to 70° according to the degree of humidity is physically best for various races; for mental activity one somewhat lower is best. Confining ourselves now to the physical, we find, for example, that factory operatives of European races in the United States work most rapidly, which means that they are strongest, when the temperature averages about 60°. For Cubans in Florida the figure is slightly higher, about 65°, but the difference is not enough to be significant. Tests of the strength of negroes in Virginia give 61° as the best average temperature, while their death-rate is least at an average of about 67°. Experiments on the amount of carbon dioxide in the breath at Manchester, England, indicate 62° as the best temperature. As the tempera-

ture of the blood is the same in all races, so it appears that almost the same outside temperature is probably best for all men, whether black, white, red, or yellow. The same appears to be true of atmospheric humidity, which has a marked effect upon man's capacity for work. A large body of evidence also indicates that changes of temperature from one day to the next as well as from season to season are highly important. In fact no matter how good a climate may be in other respects, it is open to question whether people's energy, strength of purpose, and power of achievement can remain at a high level for generation after generation except in a climate where there is the stimulus of constant change.

On the basis of the actual achievements of thousands of people under different conditions of climate, it is possible to make a map showing the amount of energy which different races would have in different parts of the world on the basis of climate alone.[1] This map is strikingly like a map of civilization. The resemblance of the two indicates that today the active and progressive races, those that dominate the world, are all located in climates which possess a highly stimulating quality. If we are right in thinking that the response to climate is almost the same among all races, the matter is highly significant in our interpretation of the fall of Rome. As we have already seen, the climatic changes which have apparently taken place in Italy appear to have been characterized by a decline in the variability of the weather from day to day, especially in the spring and summer. This means that three or four centuries B.C., Rome was blessed with a climate whose mean temperature was as good as that of today,

[1] Such a map is published in my Civilization and Climate, p. 200. The volume contains a full discussion of the relation of climate to civilization. Since it was published new facts have been discovered which show that the response of different races to climate is more uniform than was supposed when the book was written.

and which at the same time was better than that of the present, not only for agriculture, but in its stimulating effect on human activity. It apparently possessed the sparkle and tang which our own climate in the northern United States possesses to so marked a degree. If this is so, the change which took place between 300 and 200 B.C. and still more the gradual change between the time of Christ and the seventh century probably had an appreciable effect upon the energy and ability of the Roman people. Even if there had been no change in the racial composition of the inhabitants, no malaria, no agricultural distress, and no invasions of barbarians, there still would apparently have been a decline in ability. Such a decline would work particular harm at times when other conditions were becoming adverse. For instance, when irrigation was needed to overcome the difficulties of aridity, it would be particularly necessary that people should have abundant energy and initiative. These qualities would be equally needed to overcome malaria, and to prevent the streams from flooding the fields and creating swamps. Energy too would be especially valuable when the barbarians were threatening invasion, or when political questions were becoming difficult because of agricultural adversity, poverty, burdensome taxes, and consequent general discontent.

The view presented in this paper will seem to many readers to rest on foundations too slender. Even to my own mind the investigation of the relation of climate to human efficiency has brought results so surprising that I find it difficult to remodel my preconceived conceptions. Whether the hypothesis here advanced is right or wrong, it at least has a sufficient foundation to warrant further study. It does not explain why men of genius arise, why political and social institutions evolve,

or why a large part of the events of history occur. It does, however, offer a possible explanation of some of the most puzzling phases of the decline and fall of nations. The test of its accuracy lies along three lines. (1) Geographers must work out far more accurately than has yet been done the exact sequence of changes of climate, their degree of severity, and their nature. (2) Ecologists and physiologists must determine how much of human energy depends on inherited capacity and training, and how much upon physical environment, and especially upon conditions of temperature, humidity, and other climatic elements such as the amount of ozone or electricity in the air. (3) There is a vast field for economists and historians. The geographer may point out the results which he expects at certain epochs because of the climatic conditions. It rests with the historian and economist to determine whether the expected results have actually occurred. It also rests with them to scan the pages of history for the almost innumerable facts which bear on this problem. Gradually the world is seeing how intimately physical, mental, and moral traits are related, and how each reacts upon the other. The lessons of history cannot rightly be understood until the combined work of men in many lines gives us a clear idea of each one of the complex factors leading to such great events as the fall of Rome.

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